

# Space Radiation Shielding Technology Workshop

## **An Overview**

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# Brief History of Space Radiation Shielding Technology

- **1960's: the Apollo program**
  - Protection requirements for Solar particle event (SPE) from biology
  - Radiation physics applied to meet requirements
  - Physicist meets the biologist
- **1970's: increased concern for long-term exposures**
  - Skylab LEO exposures and late biological effects
  - Growing awareness of potential injury by galactic cosmic rays (GCR)
  - Track structure of high charge and energy (HZE) ions affecting biology
  - Target fragmentation events in biological tissues
  - Biologist meets the physicist
- **1980's is a period of growth in biology and radiation physics**
  - Transition to biomolecular basis for space radiation biology
  - Integration of physics and biomolecular models
  - Physicist and biologist work integrated tasks

# Brief History of Space Radiation Shielding Technology

A parallel universe

- **1960's: the Apollo program**
  - Protection requirements for Solar particle event (SPE) from biology
  - Radiation shielding affects design and operations
  - Engineer meets the physicist
- **1970's to 1980's: increased concern for long-term exposures**
  - Skylab LEO and deep space long-term exposures
  - Cell lethality in HZE exposures raises concerns for shielding
  - GCR shielding identified as major impact on design processes
  - Physicist meets the engineer
- **1990's is a period of growth in engineering and radiation physics**
  - Transition to integrated engineering design processes
  - Multidisciplinary-multifunctional design optimization
  - Non-local engineering environments for design collaboration
  - Physicist and engineers begin to work integrated tasks (faster, better, cheaper)

# 1995 JSC Workshop: Shielding Strategies for Human Space Exploration

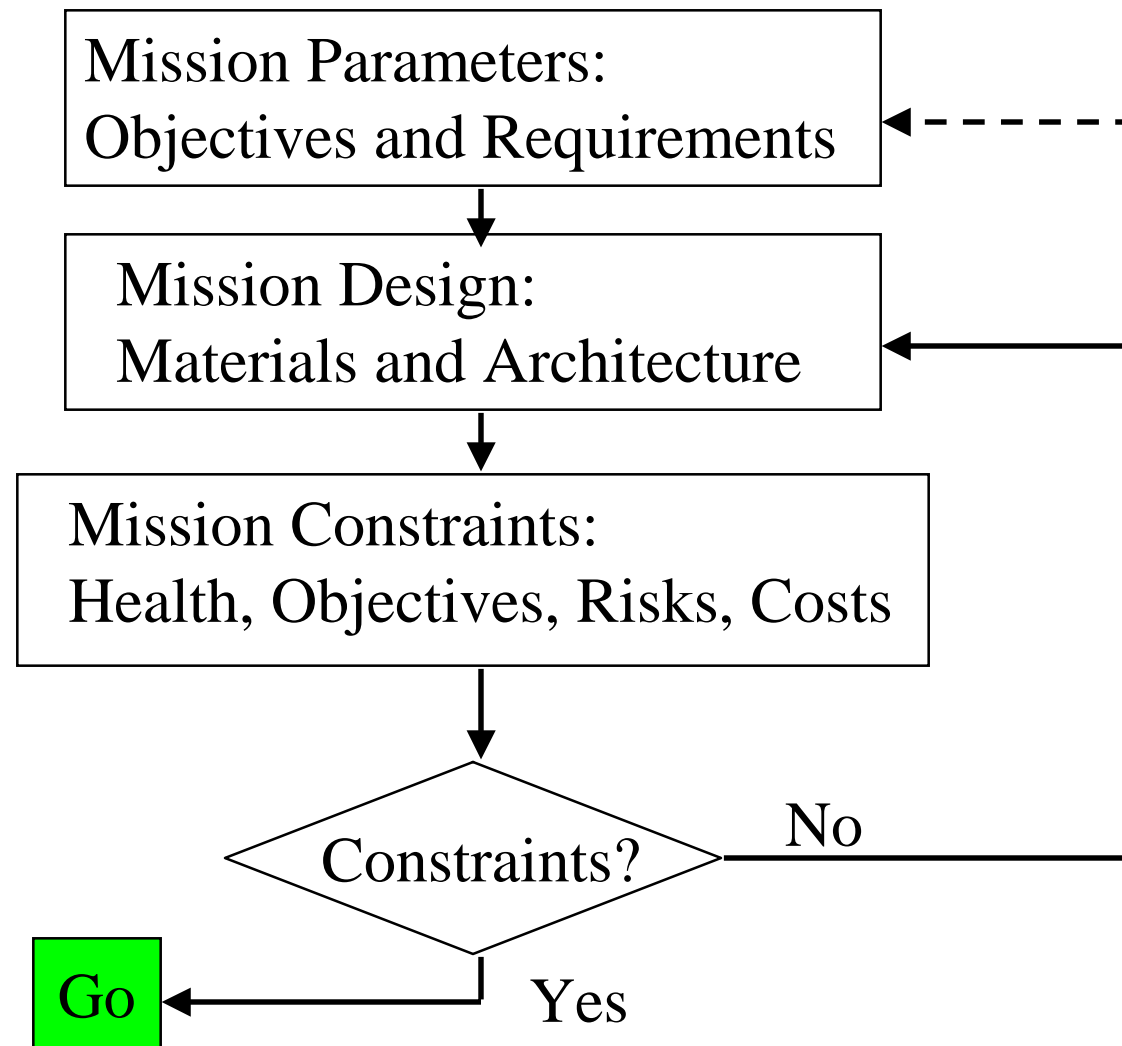
- 25 percent of participants were engineers with no prior radiation related experiences
- Emphasis on engineering design processes and requirements
- Clear need for an integrated approach to design was indicated
- Traditional radiation physics and radiation biology were still a major part of the issues addressed
- Recommendations were in two sections:
  - Radiation physics issues
  - Engineering design related issues
- A greater collaboration between radiation physicists and the engineering community has been the result

**1995 JSC Workshop: Shielding Strategies for Human Space Exploration plus**

# **An Approach to Radiation Shield Design**

- Large fraction of radiation protection comes from basic structure and onboard equipment
- Multifunctional materials can be chosen to serve as efficient shield materials and other functional purposes
  - Noise abatement using polymer fibers or open cell polymer foams
  - Material choices and equipment arrangement can be optimized to reduce parasitic shielding requirements
  - Composite structures can be developed to incorporate highly efficient shielding material into the design
- Requires an integrated approach for the design process

# Integrated Radiation Shield Design Process



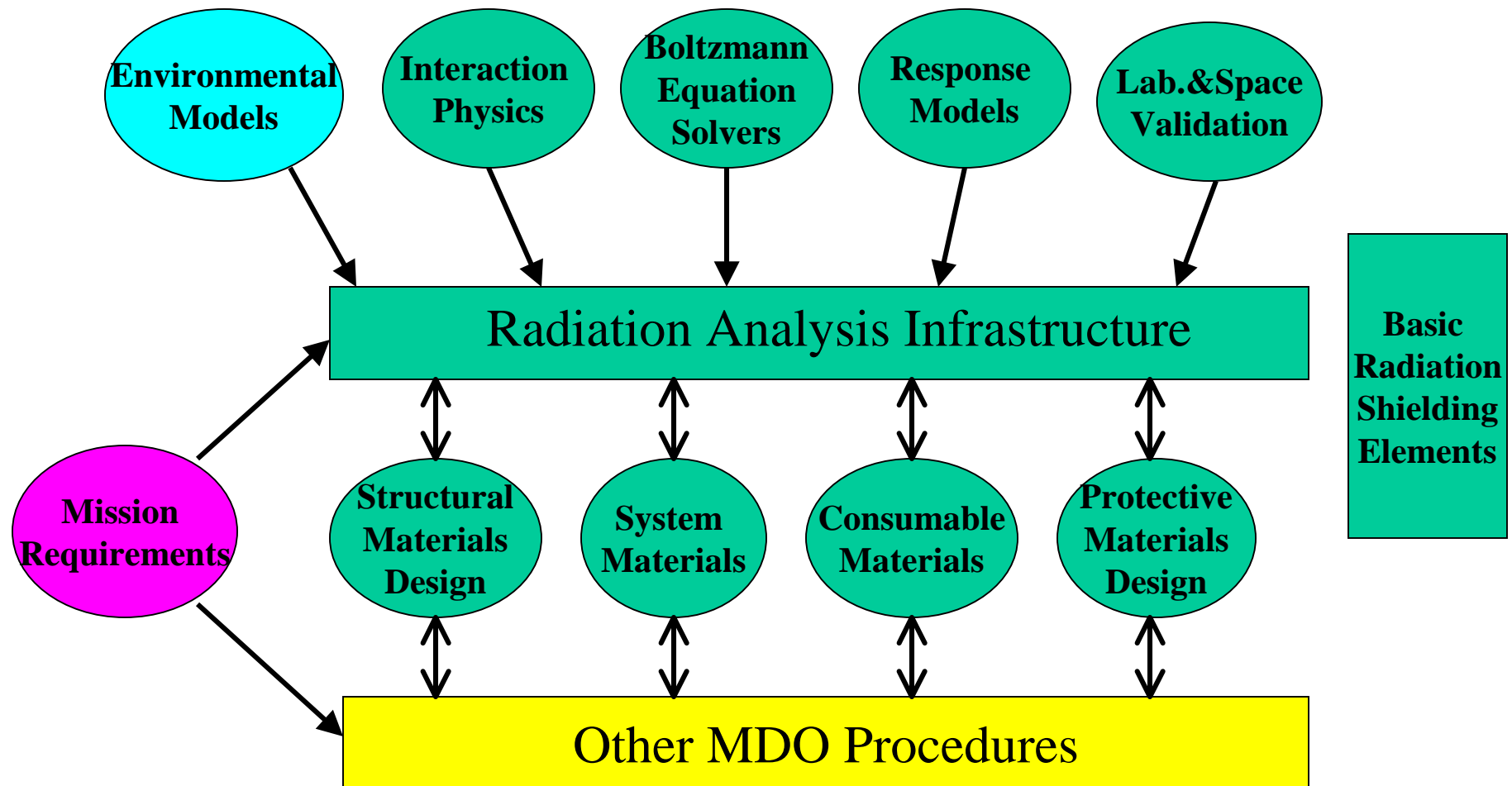
# Integrated Design Technology Requirements

- Environmental models, interaction physics, transport processes, material properties
- Materials database development and validation
- Subsystems technology development and validation
- Design tools and validation
- **High-speed computational procedures and optimization methods**
- **Multifunctional subsystems and databases**
- **Collaborative Engineering and Multidisciplinary Optimization (MDO) Methods**

The intention of this workshop is to address mainly the last items (**green**)

A modern engineering view

# MDO Paradigm for Radiation Constraints



# Integrated Systems of Multifunctional Materials to Lower Cost of Radiation Protection in the 21<sup>st</sup> Century



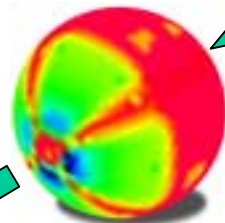
**Multidisciplinary Teams  
Using Networked  
Methods for Component  
and Subassembly  
Check-in & Verification**

**Networked Analysis Tools  
& On-the-fly Model  
Building**



**Model generation  
for multifunctional  
analysis and optimization**

**High fidelity human geometry  
and radiation response models**



**3D visualization tools  
for analysis and redesign**

**Immersive simulations**



**Immersive Audio/Visual/Collaborative  
simulation for rapid design optimization  
and crew training including Radiation  
Level, Acoustics, Structures, Thermal  
control, Aerothermal, etc.**

**Design prospectus:**

- High-fidelity computational models
- High-speed computational procedures
- Multifunctional materials database
- High-fidelity human response models
- High-reliability design methods
- Visualization of optimization pathways
- Rapid design reconfiguration processes
- Revolutionary multifunctional materials
  - Nanofibers for energy storage
  - Aliphatic/aromatic hybrid polymers
  - Self-healing polymeric systems
  - etc